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A Modeling Analysis Program for the  
JPL Table Mountain Io Sodium Cloud Data

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16. Abstract  A brief review of the massive JPL Table Mountain Io sodium cloud data set was undertaken. Images of the sodium cloud important to this modeling analysis program are contained in the 1976-1979 data set and the 1981 data set. A preliminary assessment of the 263 images in the 1981 data set for Region B/C was initiated. The spatial morphology of some of these images revealed the presence of the forward sodium cloud (Region B) and the directional features (Region C) as expected. Plans for the second quarter to initiate preliminary modeling analysis and to define further data processing are discussed.			
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## I. SUMMARY OF RESEARCH PERFORMED IN THE FIRST QUARTER

Research activities in the first quarter have been focused upon (1) an overall review of the entire data set and (2) a preliminary assessment of the set of over 200 Region B/C images obtained in the 1981 apparition.

### 1. Brief Review of the Data Set

The observing program that acquired the JPL Table Mountain Io sodium cloud data began in 1974 and continued through 1981, with useful measurements obtained each year except 1980. The observing chronology for these measurements is summarized in Table 1. Prior to 1976, observations were made only with a single slit centered on Io. Results of these observations were reported earlier by Bergstrahl et al. (1975, 1977).

Imaging observations of the Io sodium cloud have been obtained at the JPL Table Mountain Observatory since 1976. This imaging program has evolved through improvements in detectors, observing techniques, and data analysis methods. Major developments in all three of these areas in 1981 resulted in a quantum jump in both the quantity and quality of data taken. The proposed modeling analysis will focus primarily on Region B/C images from the 1981 data set, with further but selective studies of the Region B/C images in the 1976-1979 data set also included. The number of observations acquired in the 1976-1981 period is summarized in Table 2. The single slit measurements and two-dimensional images of Region A in Table 2 are also important in this modeling analysis program. They provide the information to properly calibrate the Region B/C images and also to directly link the 1976-1981 observations to the earlier 1974-1976 observations. This link is important in assessing the temporal variability/stability of the sodium cloud over the nine year period.

### 2. Preliminary Assessment of 1981 Region B/C Images

As noted in Table 2, 263 images were obtained during the 1981 apparition for Region B/C. These observations were acquired over 14 nights. The UT dates and time intervals for these observations during the 14 nights are given in Table 3. Also included in Table 3 are the values of the geocentric phase angles and system III magnetic longitudes of Io for the start and end times of

each evening. This angular information is important in classifying the spatial morphology of Region B/C and is presented in graphical form in Figure 1.

In Figure 1, the angular coverage in System III magnetic longitude of Io is excellent. The angular coverage in Io geocentric phase angle is only deficient near  $0^\circ$  and  $180^\circ$  where observational conditions are poor because of the high background light levels reflected by Jupiter's disk. As can be seen in Figure 1, there are three pairs of observations (each separated by a 32 day time interval) where the coverage in both angles is essentially identical. These three pairs provide an excellent test of the temporal variability/stability of the Io sodium cloud.

Many of the Region B/C images measured in 1981 have not been completely processed. Most of the images have been processed only preliminarily to remove the background signal. Images on May 4, 5, 12 and 13 and on June 4 have undergone further processing to remove the instrument response function and to normalize the image intensity. Because of this, the image information for observations acquired on May 4, 5, 12 and 13 has been selected by AER for preliminary assessment and evaluation. Magnetic tapes containing these images were received at AER in early August. Contour plots of many of these images have already been produced at AER and reveal both the normal structure of the forward cloud (Region B) and the presence of directional features (Region C). An example of one of these images (both in the  $D_1$  and  $D_2$  emission lines) is shown in Figure 2. This process will be continued into the next quarter, at which point preliminary modeling will be initiated.

## **II. Program for the Second Quarter**

Early in the second quarter, Bruce Goldberg will be visiting AER in order to discuss many aspects of this modeling program and the JPL Table Mountain Io sodium cloud data with William Smyth. The 1981 Region B/C images will be reviewed more thoroughly, particularly using the contour plots for the images on May 4, 5, 12 and 13. The 1976-1979 data set will be briefly reviewed and parallel information to that in Table 3 and Figure 1 will be prepared. The discussion will be designed to formulate areas for focused efforts with regard to both further data processing and modeling analysis.

The AER Io sodium cloud model will be modified to include the doppler displacement introduced in the north/south direction of the images by the

measuring instrument because of its spectral dispersion. Preliminary model runs will be performed and used to initially analyze the Region B/C images in the 1981 data set.

#### REFERENCES

Bergstrahl, J.T., Matson, D.L. and Johnson, T.V. (1975) Sodium D-Line Emission from Io: Synoptic Observations from Table Mountain Observatory. Ap. J. Lett. 195, L131.

Bergstrahl, J.T., Young, J.W., Matson, D.L. and Johnson, T.V. (1977) Sodium D-Line Emission from Io: A Second Year of Synoptic Observation from Table Mountain Observatory. Ap. J. Lett. 211, L51.

TABLE 1  
TABLE MOUNTAIN OBSERVING CHRONOLOGY: IO SODIUM PROGRAM

Observing Technique	Date	Detector	Typical Exposure Time	Measurement
Single Slit on Io	1974-76	Wampler Scanner	1 hr.	Integrated Brightness near Io
	1976-79	SIT Vidicon	40 min.	Brightness N/S along Slit
	1981	ISIT Vidicon	3 min.	Brightness N/S along Slit
Multislits 9 arc- secs E & W of Io	1976	Wampler Scanner	1 hr.	Brightness Ratios
	1976-78	SIT Vidicon	1 hr.	
2-D Imaging of Region B	1976-79	SIT Vidicon	2-3 hrs.	2-D Brightness Distributions, Cloud Dynamics, 3-D Morphology
	1981	ISIT Vidicon	10 min.	
2-D Imaging of Region A	1981	ISIT Vidicon	3 min.	2-D Brightness Distributions, Cloud Dynamics, 3-D Morphology

NOTE: All measurements were made at the coude focus of the 24-inch (61 cm) telescope. The spatial scale and spectral dispersion remained constant throughout.

Table 2

JPL Table Mountain Io Sodium Cloud Data: Number of 1976-1981 Measurements Acquired

<u>Year(s) of Observation</u>	<u>single slit (Region A)</u>	<u>multi-slit (Region B)</u>	<u>2-D images (Region B/C)</u>	<u>2-D images (Region A)</u>
1976-1979	30	8	46	-
1981	25	-	263	1153

Table 3

## 1981 Region B/C Images: Observing Chronology

<u>Observations</u>	Start Conditions				End Conditions			
	<u>Time (UT)</u>	<u>Io Phase Angle (deg)</u>	<u>Magnetic Longitude of Io<sup>†</sup> (deg)</u>	<u>Time (UT)</u>	<u>Io Phase Angle (deg)</u>	<u>Magnetic Longitude of Io<sup>†</sup> (deg)</u>	<u>Time (UT)</u>	
25 March	7:03	25.2	275.3	8:23	36.5	312.7		
5 April	5:18	89.6	365.0	7:40	109.5	70.9		
6 April	4:33	287.3	290.7	5:52	298.5	327.3		
6 April	6:38	305.1	348.5	7:44	314.4	19.1		
28 April	4:21	84.0	200.2	8:50	121.9	324.9		
29 April	3:18	279.2	117.5	7:15	312.9	227.1		
4 May	3:10	215.4	209.2	9:43	271.4	30.8		
5 May	3:17	60.0	159.4	9:25	111.7	330.2		
6 May	3:07	262.5	101.4	8:27	307.9	249.5		
12 May	3:15	44.5	147.5	8:56	92.4	305.7		
13 May	3:20	248.9	96.6	8:51	296.0	249.6		
4 June	3:34	47.2	377.3	5:48	66.0	79.5		
5 June	3:38	251.7	325.6	4:07	255.8	339.1		
5 June	5:27	267.2	16.0	5:55	271.1	29.0		
6 June	3:48	95.8	278.0	5:56	113.9	337.3		
14 June	3:38	282.7	208.4	5:20	297.1	255.7		

<sup>†</sup>System III (1965)

### Figure Captions

**Figure 1.** Observing Parameters for 1981 Io Sodium Cloud Images. The angular coverage for the Io geocentric phase angle and the system III magnetic longitude of Io over which Region B/C images were recorded in the JPL Table Mountain Data Set are indicated for all 14 nights of observations.

**Figure 2.** Io Sodium Cloud Image from the JPL Table Mountain Data. The cloud brightness is shown both in the  $D_2$  (top) and  $D_1$  (bottom) emission lines as obtained on 12 May 1980 by adding the results of three exposures, each ten minutes in duration. The mean time of the image pair, 0650 UT, corresponds to an Io geocentric phase angle of about  $75^\circ$  and a system III magnetic longitude of Io of about  $249^\circ$ . Intensity contours, from outside to inside, are 0.2, 0.5, 1, 2, 4, 6 and 8 kiloRayleighs. Contours very near the satellite decrease rapidly because of the presence of the occulting mask.

1981 IO SODIUM CLOUD IMAGE DATA  
FROM TABLE MOUNTAIN OBSERVATORY

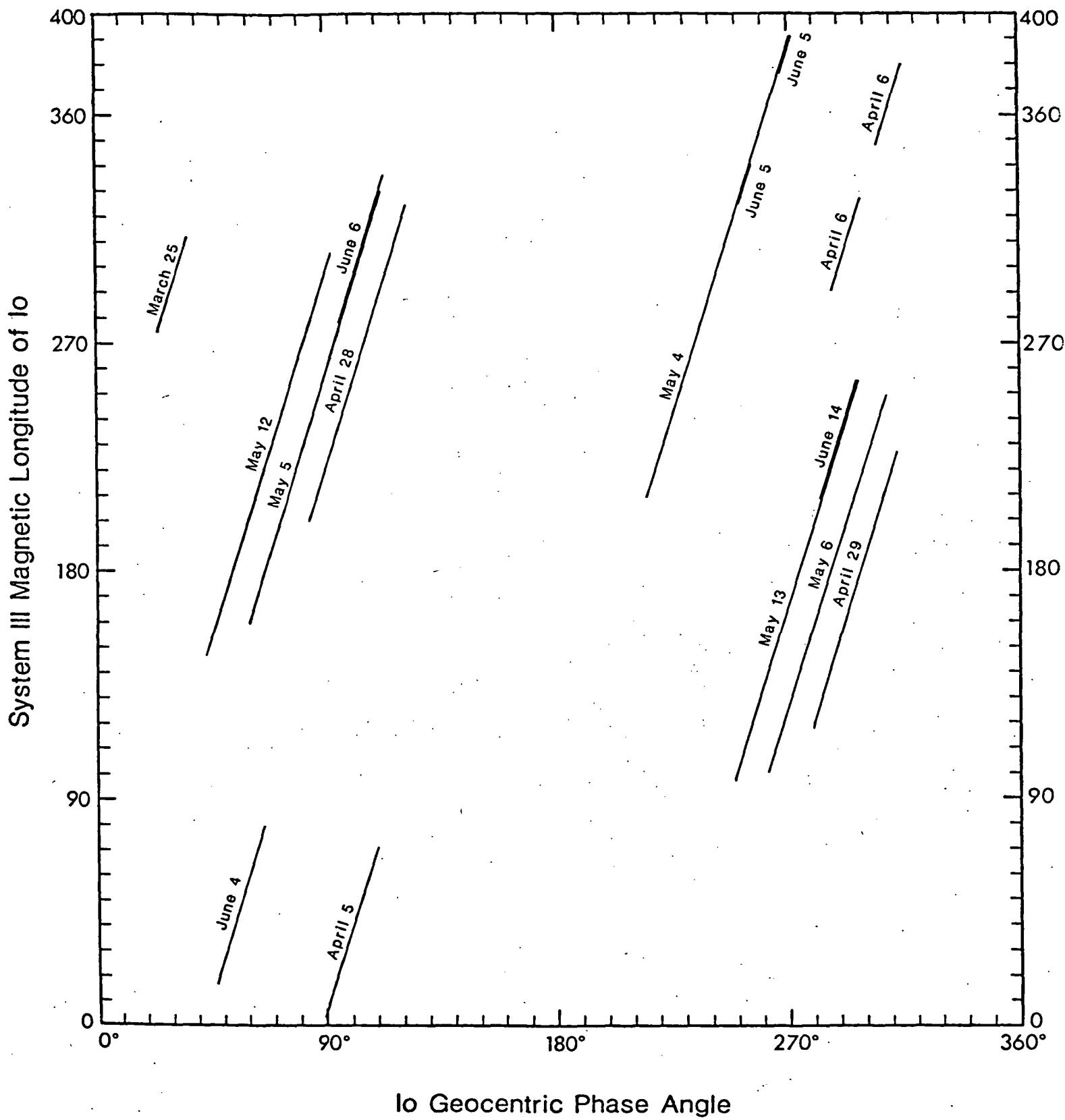


Figure 1

IO SODIUM CLOUD 1981

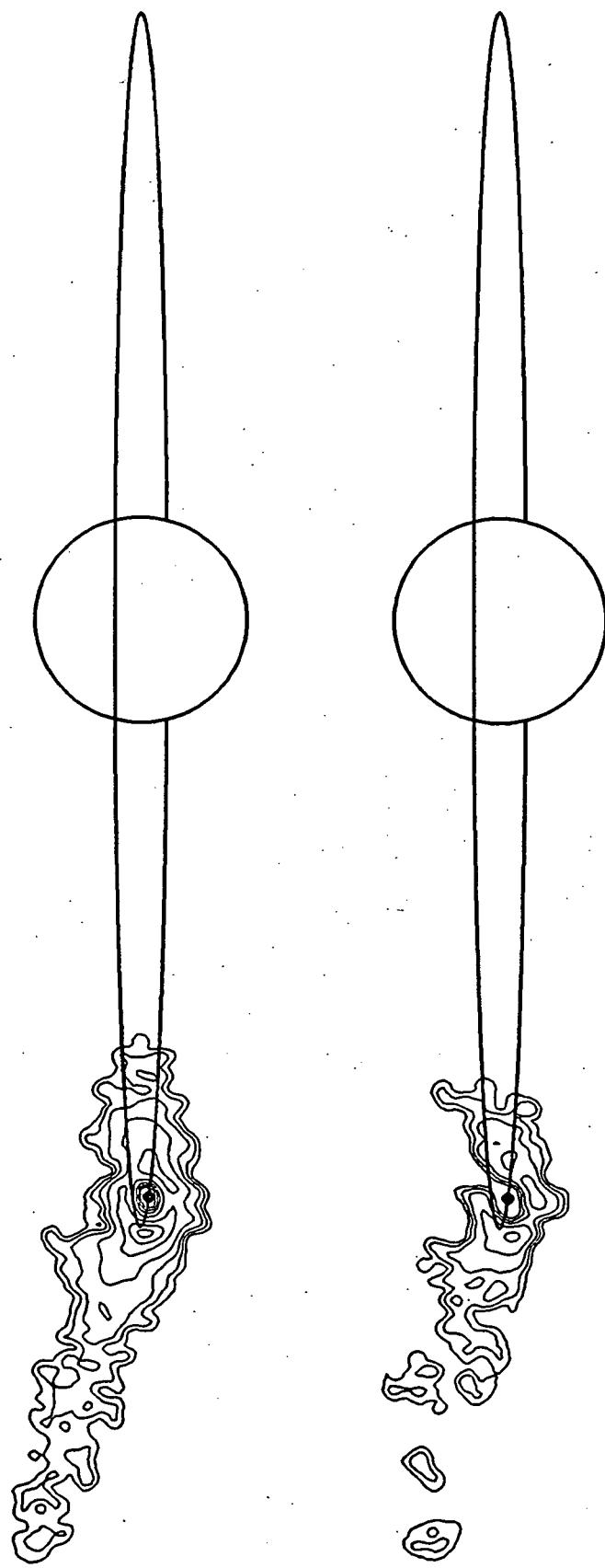


Figure 2